a structure disposed along an optical path in the cavity, the structure comprising a semiconductor material that produces nonlinear increasing loss at the operative wavelength sufficient to enhance the stability of the mode-locked output.

In the drawings:

Please substitute the enclosed formal drawings for the drawings of record.

REMARKS

Applicants' invention features incorporating into a laser cavity a semiconductor element that produces nonlinear increasing loss at the operative wavelength of the laser sufficient to enhance stability of the laser's mode-locked output. The semiconductor element can be, for example, one or more layers of a semiconductor material on a reflector. The semiconductor element produces the nonlinear increasing loss by, for example, two photon absorption or free carrier absorption.

In the Office Action, the Examiner rejects independent claims 1, 10 and 26 as anticipated by Spuhler, and independent claims 20 and 32 as obvious over Spuhler in view of Shen. The Examiner also cites Jiang '892 as "pertinent to the applicants' disclosure." These rejections are discussed separately below.

Independent Claims 1, 10 and 26

Each of claims 1, 10, and 26 requires a semiconductor element that produces nonlinear increasing loss at an operative wavelength of the laser. Claim 1, for example, recites "a semiconductor element that produces nonlinear increasing loss at the operative wavelength sufficient to enhance stability of the mode-locked output." Claim 10 recites "a reflector disposed along an optical path in the cavity, the reflector comprising...one or more layers of a second semiconductor material that produces nonlinear increasing loss at the operative wavelength to stabilize the mode-locked output." And Claim 26, a method claim, includes the step of "stabilizing the continuous train of pulses against intensity fluctuations by incorporating into the cavity a semiconductor element that produces a nonlinear increasing loss at the operative

wavelength." In one embodiment described in the applicant's specification, the semiconductor element is a thick layer of InP that produces TPA at the operative wavelength.

1. Spuhler

The Spuhler article does not disclose these elements of claims 1, 10, and 26. Spuhler simply describes a "passively mode-locked diodepumped bulk Er^{3+}:Y^{3+}:glass laser." (Spuhler, p. 569.) Spuhler's reflector includes an AlAs/GaAs backmirror with four InGaAs quantum wells grown on top of the backmirror for saturable absorption. Spuhler's mirror does not include an InP layer, or any other kind of "semiconductor element that produces nonlinear increasing loss at the operative wavelength sufficient to enhance stability of the mode-locked output."

In the office action, the Examiner labels the final GaAs layer of Spuhler's backmirror as a "semiconductor element 30," and contends that this GaAs layer satisfies the NIL producing semiconductor element of the claims. According to the Examiner:

> It is not explicitly disclosed that the semiconductor element of these claims [sic, of Spuhler] produces nonlinear increasing loss, but when the structure recited in the prior art is substantially identical to that shown in the claims, claimed properties or functions are presumed to be inherent. As the structures are the same, it is presumed that the semiconductor element will produce nonlinear loss.

(Office Action, p. 3.) The Examiner is mistaken about the structure in Spuhler—Spuhler's structure is not "the same" as or "substantially identical to" the applicants' claimed structure. Comparing Spuhler's structure to, e.g., applicants' embodiment shown in Figs. 4A-4C, both reflectors include an AlAs/GaAs backmirror and InGaAs quantum wells for mode-locking. However, Spuhler's structure entirely lacks the thick InP layer of applicants' embodiment that provides the NIL sufficient to enhance stability of the mode-locked output.

While Spuhler's backmirror may produce some small amount of incidental TPA, nothing in Spuhler suggests it will produce nonlinear increasing loss sufficient to enhance stability of the mode-locked output. Like the prior art "conventional" systems referenced in applicant's specification, Spuhler's structure will have a stability profile similar to curve 56 in Fig. 7,[1] rather

[1] There is insufficient data in the Spuhler article to determine the precise contours of the stability profile of Spuhler's reflector. However, since Spuhler lacks the TPA producing InP layer of applicants' described embodiment, there is no reason to believe Spuhler's stability profile will be substantially different than curve 56 of Fig. 7.

than an enhanced stability profile such as, e.g., curve 58. Spuhler's laser, therefore, like other prior art conventional systems, must be operated at higher power to avoid instability.

For at least the reasons discussed above, Spuhler does not disclose or suggest "a semiconductor element that produces nonlinear increasing loss at the operative wavelength sufficient to enhance stability of the mode-locked output" (claim 1); "a reflector disposed along an optical path in the cavity, the reflector comprising...one or more layers of a second semiconductor material that produces nonlinear increasing loss at the operative wavelength to stabilize the mode-locked output" (claim 10); or "stabilizing the continuous train of pulses against intensity fluctuations by incorporating into the cavity a semiconductor element that produces a nonlinear increasing loss at the operative wavelength" (claim 26). These claims, therefore, are patentable over Spuhler.

2. Jiang '892

In the first office action, mailed June 6, 2001, the Examiner cited an Optics Letter by Jiang published in August 1999. In response, applicants filed a Rule 131 affidavit which stated that an embodiment of claims 1, 10, and 26 was conceived and reduced to practice "well before August 1999." (See Thoen Affidavit, ¶¶ 1-4.) The Examiner stated that Dr. Thoen's affidavit was "sufficient to overcome the Jiang (Optics Letters, Aug. 1999) reference." (Office Action, p. 2.)

In the current office action, the Examiner cites a patent to Jiang, U.S. Patent No. 6,252,892, filed September 1998, and states that this Jiang patent "discloses everything that the previously cited Jiang reference disclosed, only the priority date is earlier." (Office Action, p. 9.)

To overcome this new Jiang reference, applicants submit the enclosed Second Affidavit of Erik R. Thoen Under 37 C.F.R. § 1.131. In this Second Affidavit, Dr. Thoen confirms that the conception and reduction to practice of claims 1, 10, and 26 occurred prior to September 1998, the filing date of the Jiang '892 reference. Thus, the Jiang '892 patent is not prior art to these claims.

Dr. Thoen's Second Affidavit also adds some additional detail, and describes an additional experiment, to make clear that claim 10 was reduced to practice prior to September 1998. In the First Affidavit, Dr. Thoen describes an experiment, at ¶ 4(c), that measured the

reflectivity of an InP InGaAsP Bragg reflector in a laser system producing radiation at 1530 nm, with 150 fs pulses. The data showed saturable absorption and nonlinear increasing loss. At ¶¶ 4(d) and 4(e), Dr. Thoen's First Affidavit stated that this experiment met all the elements of claims 1, 10 and 26.

After re-examining his notebook pages in connection with this Response, Dr. Thoen has determined that in this first experiment, the laser system was Kerr-lens mode-locked. Thus, while the data demonstrate saturable absorption and nonlinear increasing loss, the saturable absorber layers were not performing the mode-locking.

In his Second Affidavit, Dr. Thoen clarifies that this first Kerr-lens system experiment embodied all the elements of claims 1 and 26.[2] However, claim 10 provides that the reflector include "one or more layers of a second semiconductor material that acts as a saturable absorber at the operative wavelength <u>to mode-lock output of the laser</u>." As noted above, in the Kerr-lens system, the saturable absorption is not what mode-locked the laser's output.

In the Second Affidavit, therefore, Dr. Thoen describes an additional experiment performed after the reflectivity measurement (but still before September 8, 1998). This second experiment demonstrates conclusively reduction to practice of claim 10 prior to September 8, 1998.

<u>Independent Claims 20 and 32</u>

Claims 20 and 32 are directed to producing nonlinear increasing loss in an actively mode-locked laser system.

<u>1. Spuhler</u>

Claims 20 and 32, like claims 1, 10 and 26, recite inclusion of a semiconductor element or material to produce nonlinear increasing loss at the laser's operative wavelength. Claim 20 recites "a structure disposed along an optical path in the cavity, the structure comprising a semiconductor material that produces nonlinear increasing loss at the operative wavelength sufficient to enhance the stability of the mode-locked output." Claim 32, a method claim,

[2] The Second Affidavit also points out that claim 1 covers both active and passive mode-locking embodiments. The First Affidavit incorrectly suggested that claim 1 was directed only to passive mode-locking.

includes the step of "incorporating a semiconductor element into the cavity, the semiconductor element producing a nonlinear increasing loss at the operative wavelength to limit peak intensity of the pulses, and thereby suppress supermodes."

The office action rejects these claims as obvious over Spuhler in view of Shen. According to the Examiner, Spuhler satisfies all elements of the claims except for active mode-locking, and Shen "teaches that active mode locking is conventionally done using an outside modulation source, and also that active mode locking can generate pulses with small timing jitter (col. 1 lines 14-40)." The Examiner therefore concludes that it would have been "obvious to one skilled in the art to use active mode locking rather than passive mode locking because of the smaller jitter obtained, as taught by Shen." (Office Action, pp. 6-7.) Applicants disagree, for at least two reasons.

First, as discussed above, Spuhler does not describe all limitations of claims 20 and 32 other than active mode-locking. Spuhler does not disclose "a structure disposed along an optical path in the cavity, the structure comprising a semiconductor material that produces nonlinear increasing loss at the operative wavelength sufficient to enhance the stability of the mode-locked output," (claim 20), and nowhere describes or suggests "incorporating a semiconductor element into the cavity, the semiconductor element producing a nonlinear increasing loss at the operative wavelength to limit peak intensity of the pulses, and thereby suppress supermodes" (claim 32).

Second, it would not have been obvious to one skilled in the art to use Spuhler's reflector in an active mode-locked system "because of the smaller jitter obtained," as the Examiner contends. Active and passive mode-locking are different areas of research, with different underlying physics, and different real world applications. One of skill reviewing Spuhler would not have looked to active mode-locking literature, such as Shen.

In any event, had one skilled in the art reviewed both of these papers, he or she would not have been motivated to use Spuhler's reflector in an actively mode-locked system. Spuhler's reflector is specifically configured for passive mode-locking, as the paper's title suggests. Spuhler's reflector includes saturable absorbers (quantum wells) to passively mode-lock the system. In actively mode-locked systems, quantum wells are not needed for mode-locking, because an external function generator mode-locks the system.

That passive and active mode-locking are different areas of research is underscored by the applicants' development of the different embodiments of the invention. Applicants conceived and reduced to practice a passively mode-locked TPA producing embodiment first, and presented their findings at a CLEO conference in May 1999. Later, with the input an additional inventor, Mr. Grein, applicants developed the actively mode-locked embodiment described in the specification. The active mode-locking embodiment was the subject of a second CLEO presentation in 2000.

2. Jiang '892

The Jiang patent is prior art to claims 20 and 32. However, Jiang '892 describes only passively-mode locked saturable absorber reflectors. For the reasons discussed above, therefore, Jiang '892 does not describe or suggest applicants' active mode-locking claims.

Conclusion

For at least the reasons discussed above, applicants submit that independent claims 1, 10, 20, 26 and 32 are patentable over the art cited by the Examiner. The remaining claims depend from these independent claims, and are therefore patentable as well. Applicants therefore request that all pending claims be allowed.

Attached is a marked-up version of the claims amended in this response.

Enclosed is a $920 check for the Petition for Extension of Time fee. Please apply any other charges or credits to Deposit Account No. 06-1050.

Respectfully submitted,

Date: 6/18/02

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Version with markings to show changes made

In the claims:

Claims 1 and 20 have been amended as follows:

-- 1. A laser system that produces radiation at an operative wavelength, the system defining a laser cavity, and the system comprising:

a mode-locking element configured to mode-lock output of the laser system; and

a semiconductor element that produces nonlinear increasing loss at the operative wavelength <u>sufficient</u> to enhance stability of the mode-locked output. --

-- 20. A laser system that defines a laser cavity, the system comprising:

a pump;

a gain medium that produces radiation at an operative wavelength when pumped by the pump;

an element that actively mode-locks output of the laser system;

a structure disposed along an optical path in the cavity, the structure comprising a semiconductor material that produces nonlinear increasing loss at the operative wavelength <u>sufficient</u> to enhance the stability of the mode-locked output.--